

REMARKS

Applicants appreciate the Examiner's thorough examination of the present application as evidenced by the non-final Official Action of April 19, 2005 (hereinafter "the Action"). Claims 1-21 and 42-47 are pending in the present application. Claims 1, 3, 4, 6, 8-9, 20, 42 and 46 stand rejected as being anticipated under 35 U.S.C. § 102(e) by U.S. Patent No. 6,831,345 to Kinoshita et al. (hereinafter "Kinoshita"). Claims 2, 10-19, 43, 45 and 47 stand rejected under 35 U.S.C. § 103(a) as unpatentable over U.S. Patent No. 5,994,189 (hereinafter "Akiyama") in view of the Examiner's remarks. Claims 5, 7 and 44 stand rejected under 35 U.S.C. § 103(a) as unpatentable over U.S. Patent No. 6,445,054 to Trajkovic et al. (hereinafter "Trajkovic") in view of the Examiner's remarks.

As shown in the Listing of Claims, Applicants have canceled claims 1, 42, and 44-45. Applicants have amended Claim 10 to include the recitations of canceled Claim 1. Applicants have amended Claim 43 to include the recitations of canceled Claim 42. Applicants have amended Claims 2-9, 11-21 and 46 to correct dependencies changed due to the cancellation of Claims 1 and 42 and the amendment of Claims 10 and 43. Applicants have added new Claim 48. For at least the reasons set forth below, Applicants submit that all pending claims are patentable over the cited references.

Amended Claim 10 is Patentable Over Akiyama

Applicants submit that amended Claim 10 is patentable over Akiyama, for at least the reasons explained below.

Amended Claim 10 recites a silicon carbide surface charge compensation region between the floating guard rings and adjacent the insulating layer, wherein the surface charge compensation region has a dopant concentration such that the surface of the surface charge compensation region adjacent the oxide layer is partially depleted by surface charges of the oxide layer and fully depleted when a reverse bias is applied to the device, and wherein the floating guard rings extend a first distance into the silicon carbide layer and the surface charge compensation region extends a

second distance into the silicon carbide layer, the second distance being less than the first distance.

Applicants respectfully submit that to establish a prima facie case of obviousness, three basic criteria must be met. First, the prior art reference or references when combined must teach or suggest all the claim limitations. Second, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings, and there must be a reasonable expectation of success of the combination. Third, the teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. See MPEP § 2143.

Akiyama discloses a structure to reduce the on-resistance in a silicon RESURF device. See, e.g., Akiyama col. 13, ll. 47-49. A RESURF structure may be distinguished from a surface charge compensation region as recited in amended Claim 10. RESURF (REduced SURFace field) techniques are well known techniques for reducing the surface field in a power semiconductor device. As explained in the present application on page10, lines 9-21:

The surface of the surface charge compensation regions 36 will, typically, be depleted by the positive surface charges, and the negative charges in the depletion region in the surface charge compensation regions 36 will terminate the E-field lines originating from the oxide interface charges, and neutralize the negative effects of the positive interface charges. Furthermore, the amount of charge in the surface charge compensation regions 36 is small enough so that these regions can be completely depleted at a lower voltage (lower than the blocking voltage of the device), which may be required for guard rings to function properly. Therefore, surface charge compensation regions 36 may make the multiple floating guard ring termination less sensitive or insensitive to the changes in the oxide charge. Thus, operation of the surface charge compensation regions 36 according to embodiments of the present invention may function very differently from the JTE termination that utilizes the RESURF principle. App., p. 10, ll. 9-21 (emphasis added).

Accordingly, amended Claim 10 recites that the surface charge compensation region has a dopant concentration such that the surface of the surface charge compensation region adjacent the oxide layer is partially depleted by surface charges of the oxide layer and fully depleted when a reverse bias is applied to the device.

Moreover, a skilled person would not look to silicon-related art for solutions to problems relating to surface charge compensation in silicon carbide devices. As discussed in the present application, the oxide-semiconductor interface in a silicon carbide device typically has much greater charge density compared to that of a silicon device. App. p. 4, ll. 20-21.

The p- diffusion layer 5 of Akiyama is not used to compensate surface charge and does not appear to contribute to capacitively coupling the p+ regions as may be the case in a silicon carbide-based device. A skilled person would therefore have no motivation to look to Akiyama for guidance when approaching problems relating to surface charge compensation in a silicon carbide device.

Accordingly, the disclosure of Akiyama is not analogous to the problem addressed by the invention defined in amended Claim 10. Applicants therefore respectfully submit that Akiyama does not disclose or suggest the recitations of amended Claim 10, and that amended Claim 10 is patentable over Akiyama.

Claim 43 is Patentable Over Akiyama

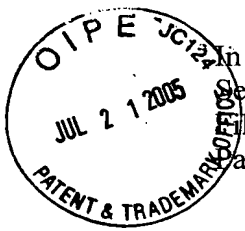
Amended Claim 43 has been amended to include the recitations of canceled Claim 42. Amended Claim 43 recites an edge termination structure for a silicon carbide semiconductor device, comprising a plurality of spaced apart concentric floating guard rings in a silicon carbide layer that surround at least a portion of a silicon carbide-based semiconductor junction; an insulating layer on the floating guard rings; and means for neutralizing effects of charges at an interface between the insulating layer and the silicon carbide layer in the region of the floating guard rings, wherein the means for neutralizing comprises means for connecting adjacent guard rings when a maximum blocking voltage is not applied to the device and isolating adjacent guard rings when the maximum blocking voltage is applied to the device.

For the reasons explained above with respect to Claim 10, Applicants respectfully submit that Akiyama does not disclose or suggest the recitations of amended Claim 43. Namely, Akiyama discloses a silicon device having a RESURF structure, while amended Claim 43 recites an edge termination structure for a silicon carbide semiconductor device, comprising a plurality of spaced apart concentric floating guard rings in a silicon carbide layer that surround at least a portion of a silicon carbide-based semiconductor junction, and means for neutralizing effects of charges at an interface between the insulating layer and the silicon carbide layer in the region of the floating guard rings. Accordingly, Applicants respectfully submit that amended Claim 43 is patentable over the cited references for at least the reasons discussed above.

Applicants further submit that dependent Claims 3-9, 11-21 and 46-48 are patentable at least as depending from patentable base claims. In addition, many of the dependent claims are separately patentable. For example, Claim 47 recites an edge termination structure wherein an amount of charge in the surface charge compensation layer is small enough so that the surface charge compensation layer is depleted at a voltage lower than a blocking voltage of the device. Likewise, new Claim 48 recites an edge termination structure wherein the means for neutralizing comprises means for capacitively coupling adjacent guard rings when a sufficient reverse bias is applied to the device. Applicants respectfully submit that the cited references do not disclose or suggest the limitations of Claims 47 and 48.

CONCLUSION

In light of the above amendments and remarks, Applicants respectfully submit that the above-entitled application is now in condition for allowance. Favorable reconsideration of this application, as amended, is respectfully requested. If, in the opinion of the Examiner, a telephonic conference would expedite the examination of this matter, the Examiner is invited to call the undersigned attorney at (919) 854-1400.



In re: Ryu et al.
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Traci A. Brown Date of Signature: July 19, 2005